

TITLE: SCRIBE LINE FORMING MECHANISM, SCRIBE HEAD, AND SCRIBE DEVICE

TECHNICAL FIELD:

[0001] The present invention relates to a scribing line forming mechanism used to form a scribing line on a substrate, a scribing head including the scribing line forming mechanism and a scribing apparatus including the scribing head.

BACKGROUND ART

[0002] For example, when a glass substrate (including a brittle material) is cut into a desired size, a cutting edge of a cutter wheel is pressed onto a surface of the brittle material with a predetermined force and is moved on the surface of the glass substrate. As a result, a scribing line is formed (hereinafter, referred to as a "scribing step"). Thereafter, a predetermined force is applied to the glass substrate along the scribing line (hereinafter, referred to as a "breaking step"). As a result, the glass substrate is cut along the scribing line.

[0003] Figure **15** shows an example of a structure of a conventional scribing apparatus **10**. The scribing apparatus **10** performs the scribing step.

[0004] The scribing apparatus **10** includes a table **11**, a first guide rail **12A**, a second guide rail **12B** and a ball screw **13**.

[0005] The table **11** is structured so as to be rotatable in a horizontal plane. A vacuum adsorption means (not shown) is provided in the table **11**. The vacuum adsorption means fixes a substrate G (e.g., brittle substrate including a glass plate) mounted on the table **11** to the table **11**. The first guide rail **12A** and the second guide rail **12B** support the table **11** such that the table **11** is movable in the Y-direction. The first guide rail **12A** and the second guide rail **12B** are provided in

parallel to each other. The ball screw **13** moves the table **11** along the first guide rail **12A** and the second guide rail **12B**.

[0006] The scribing apparatus **10** further includes a first pillar **19A**, a second pillar **19B**, a guide bar **14**, a sliding unit **15** and a motor **16**.

[0007] The first pillar **19A** and the second pillar **19B** are vertically provided on a base of the scribing apparatus **10** having the first guide rail **12A** and the second guide rail **12B** interposed therebetween. The guide bar **14** is provided above the table **11** along the X-direction and constructed between the first pillar **19A** and the second pillar **19B**. The sliding unit **15** is provided on the guide bar **14** so as to be slidable. The motor **16** slides the sliding unit **15**.

[0008] The scribing apparatus **10** further includes a scribing head **9**, a motor **17** for moving the scribing head **9** upward and downward, a first CCD camera **18A** and a second CCD camera **18B**.

[0009] The scribing head **9** is provided in the sliding unit **15**. The scribing head **9** includes a cutter wheel **29**. The first CCD camera **18A** and the second CCD camera **18B** are provided above the guide bar **14** and detect an alignment mark formed on the substrate G.

[0010] The scribing head **9** presses the cutter wheel **29** onto the surface of the substrate G. When the motor **16** slides the sliding unit **15**, the scribing head **9** moves along the guide bar **14**. As a result, the cutter wheel **29** moves on the surface of the substrate G while it is being pressed onto the surface of the substrate G, and a scribing line is formed on the surface of the substrate G.

[0011] Figure **16** shows an example of a structure of the scribing head **9**. Figure **16(a)** shows a front view of the scribing head **9**. Figure **16(b)** shows a bottom view of the scribing head **9**.

- [0012] The scribing head **9** includes a scribing head body **21**, an axle bearing **22** provided in the scribing head body **21**, a spindle **23** axially supported by the axle bearing **22**, and a restraint axis **24** provided in the scribing head body **21** and in parallel to the spindle **23**.
- [0013] The scribing head **9** further includes a bearing case **25**, an axle bearing **26**, a turning axis **27**, a cutting edge holder **28** and the cutter wheel **29**. The bearing case **25** is contactable to the restraint axis **24**. The axle bearing **26** is attached to the bearing case **25**. The turning axis **27** is axially supported by the axle bearing **26** so as to be rotatable. The cutting edge holder **28** is turnable about the turning axis **27**. The cutter wheel **29** is rotatable about a pin which is inserted at the lower end of the cutting edge holder **28**. A blade **29b** is formed so as to protrude in a V-shape toward the outer circumferential direction of the cutter wheel **29** (see Figure 20). A cutting edge's ridge **29a** is formed on the tip of the blade **29b** (see Figure 20).
- [0014] A groove **31** having a width L is formed in the bearing case **25**. A portion of the cutting edge holder **28** is embedded in the groove **31**. The turning of the cutting edge holder **28** is restricted by the range of the width L of the groove **31**.
- [0015] The scribing head **9** further includes an energizing means **30** provided in the scribing head body **21**. The energizing means **30** is, for example, an air cylinder or a servo motor. The energizing means **30** applies an energizing force to the cutter wheel **29** via the bearing case **25** and the cutting edge holder **28**.
- [0016] Figure 17 shows the cutter wheel **29**, the cutting edge holder **28** and the turning axis **27**. An attachment position of the cutter wheel **29** with respect to the turning axis **27** will be described with reference to Figure 16 and Figure 17.
- [0017] The cutter wheel **29** is axially supported by the cutter edge holder **28** so as to be rollable. The center of the rolling of the cutter wheel **29** is positioned away from

the axial center O of the turning axis **27** by an offset distance S in a direction opposite to the movement direction of the scribing head **9**.

[0018] Since the center of the rolling of the cutter wheel **29** is distant from the axial center O of the turning axis **27** by the offset distance S in a direction opposite to the movement direction of the scribing head **9**, the cutter wheel **29** moves to follow the turning axis **27**, which moves along with the scribing head **9** in a scribing step (hereinafter, the movement is referred to as a caster effect). The cutter wheel **29** is provided such that the axial center of turning axis **27** aligns with the movement direction of the cutter wheel **29** due to the rolling of the cutting edge's ridge **29a** of the cutter wheel **29** (see Figure **18** which is be described later).

[0019] Figure **18** shows a positional relationship between the cutter wheel **29** and the turning axis **27** at the time of movement of the scribing head **9**. Hereinafter, the caster effect will be described in further detail with reference to Figure **16** and Figure **18**.

[0020] When the cutter wheel **29** is contacted to the substrate G in order to start the scribing step, the direction of the cutting edge's ridge **29a** and the movement direction of the scribing head **9** (i.e., the movement direction of the turning axis **27**) do not always align with each other. Rather, in almost all of the cases, the movement direction of the turning axis **27** and the direction of the cutting edge's ridge **29a** do not coincide with each other (see Figure **18(a)** or Figure **18(c)**).

[0021] Thereafter, when the scribing head **9** moves, the direction of the cutting edge's ridge **29a** is gradually changed along with the movement of the scribing head **9**, and in a short amount of time, the direction of the cutting edge's ridge **29a** and the movement direction of the axial center O of the turning axis **27** align with each other (Figure **18(b)**). As a result, the path of the cutter wheel **29**, after the direction

of the cutting edge's ridge **29a** and the movement direction of the axis O of the turning axis **27** align with each other, is a straight line. Thus, the scribing line formed, by the cutter wheel **29**, on the substrate is a straight line. In other words, when the direction of the cutting edge's ridge **29a** of the cutter wheel **29** coincides with the axial center O of the turning axis **27**, a force, which causes the cutter wheel **29** to move toward the direction where the axial center O is positioned, is generated. Such an effect is referred to as a caster effect, and the direction of the cutting edge's ridge **29a** is gradually changed so as to align with the movement direction of the axial center O of the turning axis **27**.

[0022] Figure **19** shows a scribing line T, a vertical crack C and a horizontal crack D which are formed on the substrate G. Figure **19(a)** shows the scribing line T and the vertical crack C which are formed on the substrate G. Figure **19(b)** shows the vertical crack C and the horizontal crack D which are formed on the substrate G.

[0023] The scribing apparatus **10** forms the scribing line T having the continuous vertical crack C (see, for example, Reference 1). As the depth of the vertical crack C is deeper, the substrate G is more accurately broken along the scribing line T in a breaking step. As a result, the yield of the substrate improves.

[0024] When a load acting on the cutting edge of the cutter wheel **29** is larger, a deeper vertical crack C is formed. However, if the load acting on the cutting edge exceeds a predetermined magnitude, an internal distortion accumulated in the vicinity of the surface of the substrate G is saturated, a horizontal crack D occurs in a direction which is different from the forming direction of the vertical crack C. The horizontal crack D will cause a generation of a lot cullet powder and will cause a reduction of the yield of the substrate G which results from a poor quality of the cutting face of the substrate G.

[0025] Figure **20** shows a structure of the cutter wheel **29**. Figure **20(a)** is a front view of the cutter wheel **29**. Figure **20(b)** is a side view of the cutter wheel **29**. Figure **20(c)** is an enlarged view of a portion (portion **A**) of the cutter wheel **29** shown in Figure **20(b)**.

[0026] The cutter wheel **29** is a disk-shaped wheel (diameter ϕ , width W). The cutter wheel **29** has a first side **93** and a second side **94**. The blade **29b** with an obtuse angle ω is formed on the outer circumference of the cutter wheel **29**. The blade **29b** is formed so as to protrude in a V-shape toward the outer circumferential direction of the cutter wheel **29**. The cutting edge's ridge **29a** is formed at the tip of the blade **29b** and in the vicinity of the center of the first side **93** and the second side **94**. An insertion hole **96** is formed in the vicinity of the center of the side of the cutter wheel **29**.

[0027] A plurality of protrusions **81** and a plurality of grooves **95** are formed on the tip of the blade **29b**. The plurality of protrusions **81** and the plurality of grooves **95** have a predetermined pitch P and a predetermined height h , respectively (see Figure **20(c)**). The plurality of protrusions **81** and the plurality of grooves **95** have a size in the order of the micrometers. Thus, they cannot be identified with the naked eye.

[0028] The cutter wheel **29** possesses an extremely high capability of forming a vertical crack which extends in the thickness direction of the substrate G . The cutter wheel **29** can form a deep vertical crack and can suppress the occurrence of a crack in horizontal direction along the surface of the substrate G .

[0029] If the vertical crack is deep enough, an accurate breaking along the scribing line can be performed in the breaking step, thereby improving the yield of the substrate G . Furthermore, the breaking step becomes easier, thereby easing or

simplifying the structure of a breaking apparatus. Furthermore, it is possible to omit the breaking step.

[0030] In contrast, different from the cutter wheel **29**, a protrusion or a groove is not formed on the cutting edge's ridge portion of a conventional cutter wheel. Thus, the conventional cutter wheel cannot form a vertical crack deep enough. As a result, the breaking step cannot be omitted.

[0031] Reference 1: Japanese Laid-Open Publication No. 2001-328833

[0032] Reference 2: Japanese Laid-Open Publication No. 9-188534

DISCLOSURE OF THE INVENTION

[0033] However, it is difficult to provide the cutter wheel **29** such that the axis O of the turning axis **27** is precisely positioned on a line extending from the rolling direction of the cutting edge's ridge **29a**.

[0034] For example, due to processing error of grinding the cutter wheel **29** (material is, for example, a super-hard alloy), the cutting edge's ridge **29a** is not always formed in just the middle of the thickness of the cutter wheel **29**. Thus, the axial center O of the turning axis **27** is not always positioned on the line extending from the rolling direction of the cutting edge's ridge **29a** of the cutter wheel **29**.

[0035] For example, in order to allow the rotation of the cutter wheel **29**, it is necessary to provide a gap between the cutting edge holder **28** and the cutter wheel **29**. Thus, the line extending from the cutting edge's ridge **29a** of the cutter wheel **29** and the axial center O of the turning axis **27** of the cutting edge holder **28** do not cross each other. There is a presence of a slight gap at least about 0.01 mm between the line extending from the cutting edge's ridge **29a** of the cutter wheel **29** and the axial center O of the turning axis **27** of the cutting edge holder **28** in a direction perpendicular to the movement direction of the scribing head **9**.

[0036] Figure 21 shows: the offset distance S between the cutter wheel 29 and the turning axis 27; a gap width δ between the cutting edge's ridge 29a of the cutter wheel 29 and the axial center O of the turning axis 27; and a gap angle γ of the turning axis 27 with respect to the movement path of the cutter wheel 29. Figure 21(a) shows the offset distance S and the gap width δ . Figure 21(b) shows the offset distance S and the gap angle γ .

[0037] When the scribing head 9 is moved from the state shown in Figure 21, owing to the caster effect which occurs between: the contacting point between the cutter wheel 29 and the substrate G ; and the axial center of the turning axis 27, the cutter wheel 29 is moved from the position shown in Figure 21(a) to the position shown in Figure 21(b). However, as shown in Figure 21(b), while the center of the cutting edge of the cutter wheel 29 is positioned on the line extending in the movement direction of the axial center O , the direction of the cutting edge's ridge 29a is deviated by the gap angle γ with respect to the movement direction of the axial center O . Therefore, the cutter wheel 29 tries to roll along the line extending from the cutting edge's ridge 29a of the cutter wheel 29. As a result, the cutter wheel 29 tries to return from the position shown in Figure 21(b) to the position shown in Figure 21(a). Thus, the cutter wheel 29 meanders between the position shown in Figure 21(a) and the position shown in Figure 21(b). As a result, the movement path (i.e., scribing line) of the cutter wheel 29 meanders.

[0038] Due to the meandering of the cutter wheel 29, a force in the horizontal direction is applied to the substrate, and the horizontal crack D is formed on the substrate. The horizontal crack D will cause a generation of a lot of cullet powder and will cause a reduction of the yield of the substrate G which results from a poor quality of the cutting face of the substrate G . Even when a substrate G is cut along

a straight line, if the scribing line meanders, a cut face with a high degree of straightness cannot be obtained.

[0039] The present invention is made in view of the problems described above. The objective of the present invention is to provide: a scribing line forming mechanism capable of improve a straightness accuracy of the movement path of a scribing line forming means and preventing the occurrence of a horizontal crack; a scribing head including the scribing line forming mechanism; and a scribing apparatus including the scribing head.

[0040] A scribing line forming mechanism according to the present invention includes: a scribing line forming means being structured so as to form a scribing line on a substrate by contacting the substrate; and a supporting means for supporting the scribing line forming means such that the scribing line forming means is turnable about a first turning axis, the supporting means being structured so as to be turnable about a second turning axis, the second turning axis being different from the first turning axis, wherein the axial center of the first turning axis and the axial center of the second turning axis are approximately in parallel, and the axial center of the second turning axis is distant by a predetermined interval from a portion where the substrate and the scribing line forming means contact each other, thereby the objective described above being achieved.

[0041] According to the scribing line forming mechanism of the present invention, the scribing line forming means follows the movement direction of the second turning axis owing to the caster effect, and at the same time, the scribing line forming means can turn in a manner such that the difference (gap angle) between: a direction in which a pulling force acts between the second turning axis and the scribing line forming means; and a direction in which the scribing line forming means

moves is smaller, the gap angle resulting from an error (gap width) between the scribing line forming means and a supporting means. As a result, it is possible to reduce the friction which acts in the horizontal direction of the substrate between the scribing line forming means and the substrate, thereby preventing the occurrence of a horizontal crack. It is possible to suppress the meandering of the scribing line forming means and form a scribing line with a high degree of straightness on the substrate.

[0042] The scribing line forming means may include a cutter wheel, and the supporting means may include a cutter supporting means for the cutter wheel such that the cutter wheel is rotatable. The cutting edge of the cutter wheel turns about the first turning axis and immediately aligns with the direction of the movement path of the first turning axis. Thereafter, in accordance with the movement of the cutting edge, the movement path of the cutting edge promptly overlaps the movement path of the second turning axis. Thus, it is possible to form a scribing line with a high degree of straightness on the substrate.

[0043] The supporting means may include a bearing for supporting the scribing line forming means. Since the scribing line forming means is supported by a bearing, the turning about the turning axis is smoothly carried out.

[0044] A scribing head according to the present invention includes: the scribing line forming mechanism described above; and a pressure application means for applying a pressure force to the scribing line forming mechanism in order to the scribing line forming means to the substrate, thereby the objective described above being achieved.

[0045] According to the scribing head of the present invention, it is possible to suppress the meandering when the scribing line forming means moves and prevent an uneven scribing pressure from being applied to the scribing line forming means.

[0046] The scribing head further may include a first supporting means for supporting the supporting means such that the supporting means is turnable about the second turning axis; and a restriction means for restricting the scribing line forming means approaching the substrate, wherein the first supporting means is structured so as to be turnable about a third turning axis, the third turnable axis having an axial center vertical to the axial center of the second turning axis, the restriction may include a restraining means, the restraint means being structured so as restrain the turning of the first supporting means about the third turning axis and such that a portion of the first supporting means contact the restraining means.

[0047] The first supporting means may include a turning restriction means for restricting the turning of the supporting means about the second turning axis.

[0048] The turning restriction means may be formed in a portion of the first supporting means so as to be able to accommodate at least a portion of the scribing line forming means.

[0049] A scribing apparatus according to the present invention includes: a scribing head according to claim 4; and a moving means for moving the scribing head on a surface, the surface being approximately parallel to the substrate, such that the scribing line forming means forms the scribing line on the substrate, thereby the objective described above being achieved.

[0050] According to the scribing apparatus of the present invention, it is possible to suppress the meandering when the scribing line forming means moves and prevent an uneven scribing pressure from being applied to the scribing line forming means.

[0051] According to the scribing line forming mechanism, the scribing head and the scribing apparatus of the present invention, the scribing line forming means follows the movement direction of the second turning axis owing to the caster effect, and at the same time, the scribing line forming means can turn in a manner such that a gap angle (angle between: a direction in which a pulling force acts between the second turning axis and the scribing line forming means; and a direction in which the scribing line forming means moves), which results from an error between the scribing line forming means and a supporting means, is smaller. As a result, it is possible to reduce the friction which acts in the horizontal direction of the substrate between the scribing line forming means and the substrate, thereby preventing the occurrence of a horizontal crack. It is possible to suppress the meandering of the scribing line forming means and form a scribing line with a high degree of straightness on the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] Figure 1 is a diagram showing an example of a structure of a scribing apparatus **100** according to an Embodiment of the present invention.

[0053] Figure 2 is a diagram showing an example of a structure of a scribing head **200** according to the Embodiment of the present invention.

[0054] Figure 3 is a diagram showing the detail of the structure of a scribing line forming mechanism **201**.

[0055] Figure 4 is a diagram showing a positional relationship between a scribing line forming means **207** and a second turning axis **202** at the time of movement of the scribing head **200**.

[0056] Figure 5 is a flowchart showing a scribing line forming process procedure for forming a scribing line on a substrate G.

- [0057] Figure **6** is a diagram showing a structure of a gear-type scribing head **400** which is another example of the scribing head.
- [0058] Figure **7** is a diagram showing a controlling process procedure for controlling the gear-type scribing head **400**.
- [0059] Figure **8** is a diagram showing a structure of a direct-coupled-type scribing head **600** which is another example of the scribing head.
- [0060] Figure **9** is a diagram showing a structure of a cylindrical cam-type scribing head **500** which is another example of the scribing head.
- [0061] Figure **10** is a diagram showing a structure of a scribing head **200'** which is another example of the scribing head.
- [0062] Figure **11** is a diagram showing a structure of a scribing head **400'** which is another example of the scribing head.
- [0063] Figure **12** is a diagram showing a structure of a scribing head **600'** which is another example of the scribing head.
- [0064] Figure **13** is a diagram showing a structure of a scribing head **500'** which is another example of the scribing head.
- [0065] Figure **14** is a diagram showing a structure of a scribing apparatus **800** which is another example of the scribing apparatus.
- [0066] Figure **15** is a diagram showing an example of a structure of a conventional scribing apparatus **10**.
- [0067] Figure **16** is a diagram showing an example of a structure of a scribing head **9**.
- [0068] Figure **17** is a diagram showing a cutter wheel, a cutting edge holder and a turning axis.

[0069] Figure **18** is a diagram showing a positional relationship between a cutter wheel **29** and a turning axis **27** at the time of movement of the scribing head **9**.

[0070] Figure **19** is a diagram showing a scribing line T, a vertical crack C and a horizontal crack D which are formed on the substrate G.

[0071] Figure **20** is a diagram showing a structure of the cutter wheel **29**.

[0072] Figure **21** is a diagram showing: an offset distance S between the cutter wheel **29** and the turning axis **27**; a gap width δ between the cutting edge's ridge **29a** of the cutter wheel **29** and the axial center O of the turning axis **27**; and a gap angle γ of the turning axis **27** with respect to the movement path of the cutter wheel **29**.

[0073] **100** scribing apparatus

[0074] **111** table

[0075] **112A** first guide rail

[0076] **112B** second guide rail

[0077] **113** ball screw

[0078] **114** guide bar

[0079] **115** sliding unit

[0080] **116** first motor

[0081] **117** second motor

[0082] **118A** first CCD camera

[0083] **118B** second CCD camera

[0084] **119A** first pillar

[0085] **119B** second pillar

[0086] **200** scribing head

[0087] **201** scribing line forming mechanism

BEST MODE FOR CARRYING OUT THE INVENTION

[0088] Hereinafter, Embodiments of the present invention will be described with reference to the accompanying drawings.

[0089] 1. Scribing apparatus

[0090] Figure 1 shows an example of a structure of a scribing apparatus **100** according to an Embodiment of the present invention. The scribing apparatus **100** includes a table **111**, a first guide rail **112A**, a second guide rail **112B** and a ball screw **113**.

[0091] The table **111** is structured so as to be rotatable in a horizontal plane. A vacuum adsorption means (not shown) is provided in the table **111**. The vacuum adsorption means fixes a substrate G (e.g., brittle substrate including a glass plate) mounted on the table **111** to the table **111**. The first guide rail **112A** and the second guide rail **112B** support the table **111** such that the table **111** is movable in the Y-direction. The first guide rail **112A** and the second guide rail **112B** are provided in parallel to each other. The ball screw **113** moves the table **111** along the first guide rail **112A** and the second guide rail **112B**.

[0092] The scribing apparatus **100** further includes a first pillar **119A**, a second pillar **119B**, a guide bar **114**, a sliding unit **115**, a first motor **116** and a second motor **117**.

[0093] The scribing apparatus **100** further includes a scribing head **200**, a first CCD camera **118A**, a second CCD camera **118B**. The scribing head **200** is provided in the sliding unit **115**. The scribing head **200** includes a scribing line forming mechanism **201**.

[0094] The first pillar **119A** and the second pillar **119B** are vertically provided on a base of the scribing apparatus **100** having the first guide rail **112A** and the second guide rail **112B** interposed therebetween. The guide bar **114** is provided above the

table **111** along the X-direction and constructed between the first pillar **119A** and the second pillar **119B**. The sliding unit **115** is provided on the guide bar **114** so as to be slidable. The first motor **116** slides the sliding unit **115** along the guide bar **114**. The second motor **117** moves the scribing line forming mechanism **201** upward and downward.

[0095] The scribing head **200** presses the scribing line forming mechanism **201** onto the surface of the substrate G. When the motor **116** slides the sliding unit **115**, the scribing head **200** moves along the guide bar **114**. As a result, the scribing line forming mechanism **201** moves on the surface of the substrate G while it is being pressed onto the surface of the substrate G, and the scribing line forming mechanism **201** forms a scribing line on the surface of the substrate G.

[0096] The first CCD camera **118A** and the second CCD camera **118B** are provided above the guide bar **114** and detect an alignment mark formed on the substrate G.

[0097] The scribing apparatus **100** according to the Embodiment includes one scribing head **200**. However, the number of the scribing head included in the scribing apparatus **100** is not limited to one. The number of the scribing head included in the scribing apparatus **100** is arbitrary. For example, when the scribing apparatus **100** includes a plurality of scribing heads **200**, a plurality of scribing lines are simultaneously formed on a first surface of the substrate G and a second surface which is opposite to the first surface.

[0098] 2. Scribing head

[0099] Figure **2** shows an example of a structure of a scribing head **200** according to the Embodiment of the present invention. Figure **2(a)** shows a front view of the scribing head **200**. Figure **2(b)** shows a bottom view of the scribing head **200**.

- [00100] The scribing head **200** includes a scribing head body **221**, a third axle bearing **222** provided in the scribing head body **221**, a third spindle **223** axially supported by the third axle bearing **222**, and a restraint axis **224** provided in the scribing head **221** and in parallel to the third spindle **223**.
- [00101] The scribing head **200** further includes a bearing case **225** and an axle bearing **226**. The bearing case **225** is contactable to the restraint axis **224**. The second axle bearing **226** is attached to the bearing case **225**.
- [00102] The scribing head **200** further includes a scribing line forming mechanism (cutting edge holder) **201**. The scribing line forming mechanism **201** includes a second turning axis **202**, a holder **203**, a first turning axis **204**, a holder body **205**, a pin **206**, a scribing line forming means (cutter wheel) **207** and a first axle bearing **208**. The scribing line forming mechanism **201** will be described later in detail.
- [00103] A recessed portion M is formed in the bearing case **225** such that the holder **203** can be inserted therein. An insertion opening is formed in the back of the recessed portion M. The insertion opening is used for inserting a bearing attached to the second turning axis **202** therein. The second turning axis **202** is inserted into the bearing insertion opening at the lower surface of the bearing case **225** via the bearing.
- [00104] A groove **231** having a width L is formed in the bearing case **225**. A portion of the holder body **205** is embedded in the groove **231**. The turning about the first turning axis **204** of the scribing line forming mechanism **201** is restricted by the range of the width L of the groove **231**.
- [00105] The scribing head **200** further includes an energizing means **230** provided in the scribing head body **221**. The energizing means **230** is, for example, an air cylinder or a servo motor. The energizing means **230** applies an energizing force to

the scribing line forming means **207** via the bearing case **225** and the cutting edge holder **205**.

[00106] 3. Scribing line forming mechanism

[00107] Figure **3** shows the detail of the structure of the scribing line forming mechanism **201**. The scribing line forming mechanism **201** includes, for example, a cutting edge holder for holding a cutting edge which is pressed onto the substrate G.

[00108] Hereinafter, the structure of the scribing line forming mechanism **201** will be described in detail with references to Figure **2** and Figure **3**. The arrow shown in Figure **2** and Figure **3** shows the movement direction of the scribing head **200** and the scribing line forming mechanism **201** in the scribing step.

[00109] The second turning axis **202** is provided on the upper surface of the holder **203**. The first turning axis **204** is provided on the holder body **205**. The first axle bearing **208** holds the holder body **205** via the first turning axis **204** such that the holder body **205** is turnable in the recessed portion provided at the lower surface of the holder **203**.

[00110] The scribing line forming means **207** includes, for example, a cutter wheel. The scribing line forming means **207** is structured so as to form a scribing line on the substrate G by contacting the substrate G. The scribing line forming means **207** is axially supported so as to be rotatable via the pin **206** which is provided at the lower portion of the holder body **205**.

[00111] The first turning axis **204** is provide at the lower surface of the holder **203**. An axial center R of the first turning axis **204** is positioned away by the offset distance S from an axial center Q of the second turning axis **202** in a direction opposite to the movement direction (the arrow direction shown in Figure **3**) of the scribing line forming mechanism **201**□ The first turning axis **204** is axially supported

by the first axle bearing **208** so as to be rotatable. The first turning axis **204** is provided such that the axial center R of the first turning axis **204** crosses an axial center of the pin **206**.

[00112] The scribing line forming means **207** is provided such that the contacting point between the scribing line forming means **207** and the substrate G (hereinafter, processing contacting point) is positioned on a line extending from the axial center R of the first turning axis **204**. Thus, the scribing line forming mechanism **201** is provided in the scribing head such that the axial center of the first turning axis **204** is approximately vertical to the surface of the substrate G.

[00113] 4. Positional relationship between the scribing line forming means and the second turning axis

[00114] Figure **4** shows a positional relationship between the scribing line forming means **207** and the second turning axis **202** at the time of movement of the scribing head **200**.

[00115] Hereinafter, the transition of the positional relationship between the scribing line forming means **207** and the second turning axis **202** at the time of movement of the scribing head **200** will be described with reference to Figure **2** to Figure **4**. The substrate G is, for example, a glass substrate.

[00116] The scribing line forming mechanism **201** is attached to the scribing head **200**. While there is a presence of a slight gap width δ between a cutting edge's ridge **207a** of the scribing line forming means **207** and the axial center Q of the second turning axis **202**, the scribing line forming means **207** starts forming a scribing line on the substrate G (see Figure **4(a)**).

[00117] When the scribing head **200** is moved, a processing reaction force in scribing the substrate G acts on the scribing line forming mechanism **201** via the pin **206**.

Since the scribing line forming means **207** is provided such that the axial center R of the first turning axis **204** approximately right above the processing contacting point of the scribing line forming means **207** is positioned, the scribing line forming means **207** rotates about the axial center R of the first turning axis **204**, and the cutting edge's ridge **207a** of the scribing line forming means **207** turns in a direction in which a balance would be obtained for the processing reaction force received by the scribing line forming means **207** at the processing contacting point (see Figure **4(b)**).

[00118] Specifically, the direction of line of action on which a pulling force for pulling the scribing line forming means **207** by the scribing head **200** works and the direction of the cutting edge's ridge **207a** of the scribing line forming means **207** align with each other. Since the rotating radius is extremely small (the axial center R of the first turning axis **204** and the processing contacting point approximately align with each other), the cutting edge's ridge **207a** of the scribing line forming means **207** turns in a direction in which a balance for the processing reaction force would be obtained even if the scribing head **200** is slightly moved.

[00119] Furthermore, when the scribing head **200** is moved, the scribing line forming mechanism **201** turns about the axial center Q of the second turning axis **202** anti-clockwise from a state where the cutting edge's ridge **207a** of the scribing line forming means **207** is tilted by a slight angle α with respect to the movement path (line V) of axial center Q of the second turning axis **202** (see Figure **4(b)**). Therefore, the angle α between the cutting edge's ridge **207a** of the scribing line forming means **207** and the movement path (line V) of the axial center Q becomes smaller (see Figure **4(c)**).

[00120] Furthermore, when the scribing head **200** is moved, the processing contacting point moves on the movement path of the axial center Q of the second turning axis **202** (Figure **4(d)**). Thereafter, while a state, in which the cutting edge's ridge **207a** of the scribing line forming means **207** and the axial center Q of the second turning axis **202** align with each other, is held, the scribing line forming means **207** continues forming a scribing line (see Figure **4(d)**).

[00121] Hereinafter, the operation of the scribing line forming means **201** depends on the magnitude of the change of processing reaction force which acts on the scribing line forming line means **207** with reference to Figure **2** to Figure **4**. The operation of the scribing line forming means **201** will be described by dividing it into three situations ([Situation 1] to [Situation 3]) shown below.

[00122] As a situation in which a processing reaction force changes, for example, there is a situation in which another scribing line is formed so as to cross a previously formed scribing line.

[00123] [Situation 1] When the change of the processing reaction force is small.

[00124] The scribing line forming means **207** turns about the axial center R of the first turning axis **204**, and the cutting edge's ridge **207a** of the scribing line forming means **207** turns about a new balanced position. In other words, the scribing line forming mechanism **201** turns in a manner such that the cutting edge's ridge **207a** of the scribing line forming means **207** is directed in a line connecting the axial center Q and the processing contacting point of the scribing line forming means **207**.

[00125] As described with reference to Figure **4**, the axial center R of the first turning axis **204** and the processing contact point approximately align with each other. In other words, the turning radius is extremely small. Thus, even when the scribing head **200** is slightly moved, the scribing line forming means **207** moves to a newly

balanced position of a processing reaction force received by the scribing line forming means **207**.

[00126] [Situation 2] When the change of the processing reaction force is larger than that in Situation 1.

[00127] The scribing line forming means **207** moves about the axial center Q of the second turning axis **202** while rotating. Immediately after the movement, the difference between the processing reaction forces received by cutting faces on left and right sides of the scribing line forming means **207** is minimum. Thus, the scribing line forming means **207** moves to the position where the balance of the processing reaction force received by the scribing line forming means **207** is the most stable. Therefore, the scribing line forming means **207** turns about the first turning axis **204**, and the scribing line forming mechanism **201** operates in a manner such that a direction of a straight line which connects the processing contacting point and the axial center Q of the second turning axis **202** and a rotating movement direction of the cutting edge's ridge **207a** of the scribing line forming means **207** align with each other. Thus, a scribing situation in Situation 2 is the same as the one in Situation 1.

[00128] [Situation 3] When the processing reaction force does not change.

[00129] Similar to the caster effect in the case of $\delta=0$, the cutting edge's ridge **207a** of the scribing line forming means **207** moves closer to the movement path of the axial center Q while the scribing line forming mechanism **201** is turning about the axial center Q of the second turning axis **202**.

[00130] As described above, when a scribing is performed by the scribing head **200**, in the case of [Situation 1], a balance of the processing reaction force at the contacting point between the scribing line forming means **207** and the substrate G is

promptly obtained, based on the turning movement of the scribing line forming mechanism **201**, and an operation resulting from the caster effect similar to in the case of $\delta=0$ is immediately started. Thus, compared to the case in which a conventional scribing head is used, the magnitude of the meandering can be suppressed.

[00131] Additionally, in the case of [Situation 2], the direction of the scribing line forming means **207** is changed in a manner such that a load balance received by the scribing line forming means **207** becomes the most stable immediately after the processing contacting point is moved, and the time to be required such that the turning movement direction of the cutting edge's ridge **207a** of the scribing line forming means **207** is caused to align with the running direction of the scribing head **200** is short. Thus, compared to a conventional scribing head, a meandering distance and a meandering time are shortened. Furthermore, even after the scribing line forming means **207** is back to the movement path of the axial center Q, the rolling movement direction of the cutting edge's ridge **207a** of the scribing line forming means **207** overlaps the movement direction of the scribing head **200** (i.e., the movement direction of axial center Q). Thus, even in the case of $\delta \neq 0$ (i.e., there is a gap width resulting from an error such as a processing), if the scribing step is performed by using the scribing head **200**, it is possible to continue a stable scribing operation similar to the case in which the scribing head is when $\delta=0$.

[00132] It is difficult to make the gap width δ zero in view of processing accuracy, cost and mounting accuracy. However, according to the scribing line forming mechanism, the scribing head and the scribing apparatus of the present invention, even in the case where a scribing is performed by using a scribing line forming mechanism with which the gap width δ is not zero, at least one of the scribing line

forming mechanism **201** and the scribing line forming means **207** turns in a direction in which the direction of the cutting edge's ridge **207a** of the scribing line forming means **207** becomes immediately stable corresponding to the change of the processing reaction force. Thus, even when a large change is received, the caster effect, similar to the case where the gap width δ is zero, at the time of scribing operation can be obtained. As a result, it is not necessary to pay much attention to the precision of the processing accuracy, the mounting accuracy, and making the gap width δ zero. Therefore, there is an advantage in that the cost for manufacturing a scribing line forming mechanism can be reduced.

[00133] Furthermore, even when the gap width δ is not zero, the turning movement direction of the cutting edge's ridge **207a** of the scribing line forming means **207** aligns with the running direction of the scribing head while the scribing line forming means **207** receives a normal stable processing reaction force. Thus, an excellent scribing operation with a stable straightness is obtained.

[00134] In the Embodiment, the case has been described in which the scribing line forming means **207** starts scribing at a position, which is deviated by the gap width δ on the left side (on the upper side in Figure 4) in the moving direction of axial center Q of the second turning axis **202**, as a starting point. However, even when the scribing line forming means **207** starts scribing at a position, which is deviated by the gap width δ on the right side (on the lower side in Figure 4) in the moving direction of axial center Q of the second turning axis **202**, as a starting point, a similar effect can be obtained.

[00135] According to the scribing head **200** of the Embodiment of the present invention, a scribing line with a high degree of straightness can be formed on the substrate G.

[00136] Furthermore, according to the scribing line forming mechanism, the scribing head and the scribing apparatus of the present invention, even when there is a gap width δ between the cutting edge's ridge **207a** of the scribing line forming means **207** and the axial center Q of the second turning axis **202**, the cutting edge's ridge **207a** of the scribing line forming means **207** turns in a direction so as to overlap on a line of action on which the pulling force of the scribing head acts immediately after the starting of movement of the scribing head **200**. Therefore, the scribing line forming means **207** rolls in a manner such that a gap angle γ of the cutting edge's ridge **207a** of the scribing line forming means **207** with respect to the movement path line of the axial center Q of the second turning axis **202** (see Figure **21(b)**) promptly comes close to 0, and the cutting edge's ridge **207a** of the scribing line forming means **207** moves closer to the movement path line of the axial center Q. In this manner, along with the movement of the scribing head **200**, the scribing line forming means **207** reaches the position where it overlaps the movement path of the axial center Q of the second turning axis **202** owing to the acting caster effect, thereby a stable scribing operation being performed.

[00137] As described above, the scribing line forming mechanism, the scribing head and the scribing apparatus according to the Embodiment of the present invention has been described with reference to Figure 1 to Figure 4.

[00138] In the examples shown in Figure 1 to Figure 3, the scribing line forming mechanism **201** corresponds to a "scribing line forming mechanism", the scribing line forming means **207** corresponds to a "scribing line forming means being structured so as to form a scribing line on a substrate by contacting the substrate", the holder body **205** corresponds to a "supporting means for supporting the scribing line forming means such that the scribing line forming means is turnable about a first

turning axis, the supporting means being structured so as to be turnable about a second turning axis, the second turning axis being different from the first turning axis", the first turning axis **204** corresponds to a "first turning axis", and the second turning axis **202** corresponds to a "second turning axis". Furthermore, the scribing head **200** corresponds "a scribing head", and the energizing means **230** corresponds "a pressure application means for applying a pressure force to the scribing line forming mechanism in order to press the scribing line forming means onto the substrate". the Furthermore, the scribing apparatus **100** corresponds to a "scribing apparatus", and the first motor **116** corresponds to a "moving means for moving the scribing head on a surface, the surface being approximately parallel to the substrate, such that the scribing line forming means forms the scribing line on the substrate".

[00139] However, the scribing line forming mechanism, the scribing head and the scribing apparatus according to the Embodiment of the present invention are not limited to those shown in Figure 1 to Figure 3. A scribing line forming mechanism, a scribing head and a scribing apparatus having arbitrary structure can be included in the scope of the present invention as long as the function of each means described above is achieved.

[00140] Furthermore, each means described in the Embodiment shown in Figure 1 to Figure 3 can be implemented by hardware, software or the combination of the hardware and the software.

[00141] 5. Scribing line forming process procedure

[00142] Figure 5 show a scribing line forming process procedure for forming a scribing line on a substrate G. Hereinafter, the scribing line forming process procedure according to the present invention will be described step by step with

reference to Figure 1, Figure 2 and Figure 5. The scribing line forming process procedure is performed by a scribing apparatus **100**.

[00143] Step 101: When a table **111** is mounted on the substrate G, a vacuum adsorption means fixes the substrate G to the table **111**.

[00144] Step 102: When a first CCD camera **118A** and a second CCD camera **118B** identify an alignment mark inscribed on the substrate G, the mounting position of the substrate G is detected and the table **111** is moved such that the mounting position of the substrate G is a desired position.

[00145] For example, if it is detected that the mounting position of the substrate G is deviated from the desired position by the angle θ about the turning axis of the table **111**, the table **111** is rotated by the angle $-\theta$ about the turning axis of the table **111**.

[00146] For example, if it is detected that the mounting position of the substrate G is deviated from the desired position by a distance **a** in the Y-direction, the table **111** is moved by a distance **-a** in the Y-direction.

[00147] After the mounting position of the substrate G is moved to the desired position, the process proceeds to step 103.

[00148] Step **103**: When a first motor **116** is driven, a sliding unit **115** (scribing head **200**) is moved along a guide bar **114** to a scribing starting position. For example, the sliding unit **115** is moved such that the scribing line forming means **207** is positioned in the vicinity of the outside of the left end face of the substrate G (see Figure 1).

[00149] After the sliding unit **115** is moved to the scribing starting position, the process proceeds to step **104**.

[00150] Step **104**: When a second motor **117** is driven, the scribing head **200** moves downward until the scribing line forming means **207** reaches the position which is

located at a predetermined depth below the surface of the substrate G (e.g., position of 0.05mm to 0.20mm below the surface of the substrate G).

[00151] After the scribing line forming means **207** reaches the position which is located at the predetermined depth below the surface of the substrate G, the process proceeds to step 105.

[00152] Step 105: While a predetermined load is applied to the scribing line forming means **207** by an energizing means **230**, the first motor **116** moves the sliding unit **115** along the guide bar **114**. The scribing head **200** moves along with the movement of the sliding unit **115**, and the scribing line forming means **207** forms a scribing line.

[00153] After the scribing line forming means **207** has formed the scribing line, the process is completed.

[00154] As described above, the scribing line forming means process procedure according to the Embodiment of the present invention has been described above with reference to Figure 1, Figure 2 and Figure 5.

[00155] 6. Gear-type scribing head

[00156] Figure 6 shows a structure of a gear-type scribing head **400** which is another example of the scribing head. Figure 6(a) shows a side view of the gear-type scribing head **400**. Figure 6(b) shows a front view of relevant parts of the gear-type scribing head **400**. Figure 6(c) shows a bottom of relevant parts of the gear-type scribing head **400**. In Figure 6, the same components as those shown in Figure 2 are denoted by the same reference numerals, and the description thereof will be omitted.

[00157] The gear-type scribing head **400** includes a first side wall **401A**, a second side wall **401B**, a servo motor **402** which is fixed between the first side wall **401A**

and the second side wall **401B** in an upside down manner, an L-shaped holder holding member **404**, a spindle **403**, which is provided at the bottom portion of the first side wall **401A** and the second side wall **401B**, for supporting the holder holding member **404** such that the holder holding member **404** is rotatable, and a scribing line forming mechanism **201**.

[00158] A first bevel gear **405A** is firmly fixed to an output axis of the servo motor **402**. A second bevel gear **405B** is firmly fixed to the spindle **403**. The first bevel gear **405A** and the second bevel gear **405B** are provided so as to engage with each other. Thus, when the servo motor **402** is rotated in a positive direction or a negative direction, the holder holding member **404** turns about the spindle **403**, and the scribing line forming mechanism **201** moves upward or downward, respectively.

[00159] The gear-type scribing head **400** is provided on the guide bar **114** so as to be slidable. A recessed portion M is formed at the lower surface of the holder holding member **404** such that the holder **203** can be inserted therein. An insertion opening is formed in the back of the recessed portion M. The insertion opening is used for inserting a bearing attached to the second turning axis **202** therein. The second turning axis **202** is inserted into the bearing insertion opening at the lower surface of the bearing case **225** via the bearing.

[00160] A groove **231** having a width L is formed at the lower surface of the holder holding member **404**. A portion of the holder body **205** is embedded in the groove **231**. The turning of the scribing line forming mechanism **201** is restricted by the range of the width L of the groove **231**.

[00161] The gear-type scribing head **400** moves the scribing line forming means **207** upward and downward by controlling the position of the servo motor **402** and determines the position of the scribing line forming means **207**. When the position

of the scribing line forming means **207** set by the servo motor **402** is deviated in the X-direction, the driving torque, which works so as to move the scribing line forming means **207** back to the position of the scribing line forming means **207** set by the servo motor **402**, is restricted, and at the same time, the driving torque is transmitted to the scribing line forming means **207** as a scribing pressure.

[00162] The gear-type scribing head **400** can be applied to the scribing apparatus **100** which has been described with reference to Figure 1, instead of the scribing head **200** or in addition to the scribing head **200** which has been described with reference Figure 2. The scribing apparatus **100** including the gear-type scribing head **400** can perform the scribing line forming process procedure which has been described with reference to Figure 5.

[00163] Figure 7 shows a controlling process procedure for controlling the gear-type scribing head **400**. Hereinafter, the controlling process procedure for controlling the scribing head **400** in order to scribe the substrate G by the gear-type scribing head **400** will be described with reference to Figure 7.

[00164] Specifically, Figure 7 shows a timing-chart of the operation of the scribing line forming means **207** for forming one scribing line. Categories are: an X-axis operation (operation in which the scribing head **400** moves on the substrate); a Z-axis position setting (setting position of the scribing line forming means **207** in a vertical direction); a Z-operation (operation in which the scribing line forming means **207** moves in the vertical direction); and changes of a torque limit value (changes of the torque limit value of the servo motor **402**).

[00165] An example, in which the scribing line forming means **207** moves from the left (position a) to the right (position f) on the substrate G in order to scribe in a direction which the positional data in the X-axis increases, is shown. In the example which

will be described with reference to Figure 7, the torque of the servo motor **402** is limited based on the position data in the X-axis.

[00166] First, the position data in the X-axis is set in a control section which is included in the gear-type scribing head **400**. The position data in the X-axis includes: data showing an X-axis cutting-in position (position a); data showing an X-axis pushing-in position (position c); data showing an X-axis pushing-in completion position (position d); data showing an X-axis cutting-in completion position (position e); and data showing an X-axis scribing completion position (position f). The X-axis cutting-in position (position a), the X-axis pushing-in position (position c), the X-axis pushing-in completion position (position d), the X-axis cutting-in completion position (position e) and the X-axis scribing completion position (position f) exist between an X-axis operation starting position (position S1) and an X-axis operation completion position (position E1).

[00167] After the position data in the X-axis is set in the control section, the process proceeds to step 1.

[00168] Step 1: In the operation of the scribing line forming means **207** for forming one scribing line, a position-determining torque value is output. After the position-determining torque value is output, the process proceeds to step 2.

[00169] Step 2: The scribing line forming means **207** is moved to a Z-axis waiting position (position Z1). After the scribing line forming means **207** is moved, the process proceeds to step 3.

[00170] Step 3: At the time when the scribing line forming means **207** has moved to the X-axis cutting-in position (position a), the scribing line forming means **207** moves to a Z-axis cutting-in position (position Z2), and the position along the Z-axis of the scribing line forming means **207** is held. The Z-axis cutting-in position (position Z2)

is a position where the scribing line forming means **207** has moved downward by E from point 0 (surface of the substrate G) in the vertical direction. After the position is held, the process proceeds to step 4.

[00171] Step 4: A climbing torque limit value is set, and the servo motor **402** outputs the climbing torque limit value. In other words, when the scribing line forming means **207** moves in the horizontal direction and climbs the substrate G (position b), the position of the scribing line forming means **207** in the Z-axis cutting-in position is deviated. Thus, while IN-POS (in position) signal output from a servo amplifier is ON, the servo motor **402** tries to move the position of the scribing line forming means **207** back to the original Z-axis cutting-in position and increases the torque, thereby causing the need for limiting the climbing torque. Therefore, the climbing torque limit value is set. The climbing torque limit value is a small value such that a chip does not occur at the end of the substrate G when the scribing line forming means **207** climbs the substrate G.

[00172] Step 5: When the scribing line forming means **207** has climbed the substrate G (position b), the position of the scribing line forming means **207** of the Z-axis cutting-in position is deviated. When the IN-POS (in position) signal output from the servo amplifier is OFF, a pushing torque limit value is set at position c by a controller which issues an instruction to the servo motor (e.g., NC or sequencer) after the scribing line forming means **207** has moved by a preset predetermined distance. The servo motor **402** outputs the pushing torque limit value. If the setting position in the Z-axis remains to be the Z-axis cutting-in position, a displacement is small, and an appropriate pushing torque for scribing cannot be obtained. Thus, the setting position in the Z-axis is set at the Z-axis pushing position which is further below the Z-axis cutting-in position from the upper surface of the substrate G.

[00173] Step 6: The gear-type scribing head **400** is moved to the X-direction (position d) at a preset scribing speed by using the driving torque (which is limited to the pushing torque limit value) for trying to move to the Z-axis pushing position as a scribing pressure. When the gear-type scribing head **400** has reached position d, the process proceeds to step 7.

[00174] Step 7: The scribing speed is decreased to a cutting-through speed which can cut the substrate G. The cutting-through speed is preset. A cutting-through torque limit value is set. The servo motor **402** outputs the cutting-through torque limit value. The position in the Z-axis is set as the Z-axis cutting-in position. The cutting-through torque limit value is set as a small value as in the case of climbing such that a chip does not occur at the end of the substrate G when the scribing line forming means **207** is cutting through the substrate G (X-axis cutting-in completion position, position e).

[00175] Step 8: When the scribing line forming means **207** has cut through the substrate G (position e), the position of the scribing line forming means **207** in the vertical direction again returns to the Z-axis cutting-in position.

[00176] Step 9: When the gear-type scribing head **400** has reached position f, a position-determining torque is set, and the servo motor outputs the position-determining torque value. Then, the scribing line forming means **207** once again moves to the Z-axis waiting position. A series of scribing operations is completed.

[00177] When a scribing line is formed on the substrate G by the gear-type scribing head **400**, as previously described, the cutting edge's ridge **207a** of the scribing line forming means **207** holds the position which overlaps the movement path of the axial center Q of the second turning axis **202** run by the gear-type scribing head **400**. Therefore, a scribing line with a high degree of straightness is formed.

[00178] When the servo motor **402** is rotatively driven, it is possible to move the scribing line forming means **207** upward and downward via the holder holding member **404**. Thus, it is possible to directly act the rotating torque as a scribing pressure via the servo motor **402**, and a scribing pressure appropriate for the substrate G can be arbitrarily selected.

[00179] 7. Direct-coupled-type scribing head

[00180] Figure **8** shows a structure of a direct-coupled-type scribing head **600** which is another example of the scribing head. Figure **8(a)** shows a side view of the direct-coupled-type scribing head **600**. Figure **8(b)** shows a bottom view of the direct-coupled-type scribing head **600**. In Figure **8**, the same components as those shown in Figure **2** and Figure **6** are denoted by the same reference numerals, and the description thereof will be omitted.

[00181] The holder holding member **404** is directly coupled to an output axis of the servo motor **402**. Since the holder holding member **404** is directly coupled to the output axis of the servo motor **402**, the responsiveness of the servo motor **402** is further increased. Furthermore, since a rotating torque of the servo motor **402** is directly used as a scribing pressure, a scribing pressure appropriate for the substrate G can act on the substrate G by adjusting the rotating torque in a non-stepwise manner.

[00182] The direct-coupled-type scribing head **600** can be applied to the scribing apparatus **100** which has been described with reference to Figure **1**, instead of the scribing head **200** or in addition to the scribing head **200** which has been described with reference Figure **2**. The scribing apparatus **100** including the direct-coupled-type scribing head **600** can perform the scribing line forming process procedure which has been described with reference to Figure **5** and Figure **7**.

[00183] 8. Cylindrical cam-type scribing head

[00184] Figure 9 shows a structure of a cylindrical cam-type scribing head **500** which is another example of the scribing head. In Figure 9, the same components as those shown in Figure 2 are denoted by the same reference numerals, and the description thereof will be omitted.

[00185] The cylindrical cam-type scribing head **500** includes a servo motor **502**, a cylindrical cam **503**, a bearing **506**, a holder holding member **504**, a linear bearing **507** and a scribing line forming mechanism **201**. The servo motor **502** is fixed to a side wall **501** in an upside down manner. The cylindrical cam **503** is connected to the output axis of the servo motor **502**. The bearing **506** is axially supported so as to be rollable on a cam face **532** of the cylindrical cam **503**. The holder holding member **504** axially supports the bearing **506** such that the bearing **506** is rotatable. Additionally, the holder holding member **504** is energized in a direction toward the cylindrical cam **503** via an elastic member **505**. The linear bearing **507** is fixed to the side wall **501** and fits the holder holding member **504** by insertion in a manner such that the linear bearing **507** can move the holder holding member **504** upward and downward. The scribing line forming mechanism **201** has a second turning axis **202** axially supported such that the second turning axis **202** is turnable on a lower surface of the holder holding member **504**.

[00186] A recessed portion **M** is formed at the lower surface of the holder holding member **504** such that the holder **203** can be inserted therein. An insertion opening is formed in the back of the recessed portion **M**. The insertion opening is used for inserting a bearing attached to the second turning axis **202** therein. The second turning axis **202** is inserted into the bearing insertion opening at the lower surface of the bearing case **225** via the bearing.

[00187] A groove **231** having a width L is formed at the lower surface of the holder holding member **504**. A portion of the holder body **205** is embedded in the groove **231**. The turning of the scribing line forming mechanism **201** is restricted by the range of the width L of the groove **231**.

[00188] While the cutting edge's ridge **207a** of the scribing line forming means **207** holds the position which overlaps the movement path of the axial center Q of the second turning axis **202** run by the gear-type scribing head **500**, a scribing line is formed. Therefore, the scribing line which has been formed has a high degree of straightness.

[00189] The servo motor **502** rotates the cylindrical cam **503** by a positive direction or a negative direction. Thus, it is possible to move the holder holding member **504** upward and downward along the linear bearing via the bearing **506**. As a result, the scribing line forming mechanism **201** can be moved upward and downward.

[00190] According to the cylindrical cam-type scribing head **500**, the cylindrical cam **503** is rotated by rotatingly driving the servo motor **502**, thereby moving the holder holding member **504** via the bearing **506**. Thus, the position of the holder holding member **504** smoothly changes having a cosine curve. As a result, compared to the scribing head **400** (see Figure 6) and the scribing head **600** (see Figure 8) which change the position of the holder holding member **404** in a straight line manner, the position of the cylindrical cam-type scribing head **500** can change with a smaller amount of force, and an excellent following capability of the scribing line forming means **207** for undulations on the surface of the substrate G can be obtained.

[00191] Furthermore, according to the cylindrical cam-type scribing head **500**, it is possible to move the scribing line forming mechanism **201** of the scribing head **500** upward and downward in a straight line manner. Thus, compared to the case in

which the scribing line forming mechanism **201** is provided in the bearing case **205** and the holder holding member **404**, the change of the torque to be transmitted to the scribing line forming means **207** is small. Furthermore, the speed of moving the scribing line forming mechanism **201** upward and downward does not change.

[00192] Furthermore, the number of components that make up the cylindrical cam-type scribing head **500** is small and the mounting thereof is easy.

[00193] Furthermore, according to the cylindrical cam-type scribing head **500**, since the structure of the scribing head can be compact, there is an advantage that it can be accommodated in a small footprint space.

[00194] The cylindrical cam-type scribing head **500** can be applied to the scribing apparatus **100** which has been described with reference to Figure **1**, instead of the scribing head **200** or in addition to the scribing head **200** which has been described with reference Figure **2**. The scribing apparatus **100** including the cylindrical cam-type scribing head **500** can perform the scribing line forming process procedure which has been described with reference to Figure **5** and Figure **7**.

[00195] 9. Regarding the turning restriction of the scribing line forming mechanism

[00196] As described with reference to Figure **2**, Figure **6**, Figure **8** and Figure **9**, in the scribing head **200**, the scribing head **400**, the scribing head **600** and the scribing head **500**, the turning about the first turning axis **204** and the second turning axis **202** of the scribing line forming mechanism **201** is restricted. Specifically, a recessed portion **M** and a groove **231** are formed at the lower surface of the bearing case **225**, the holder holding member **404** and the holder holding member **504** such that the holder **203** can be inserted into the recessed portion **M** and the groove **231**, and a portion of the holder body **205** is embedded into the groove **231**. Thus, the turning of the scribing line forming mechanism **201** is restricted by the groove **231**.

[00197] However, the turning about the first turning axis **204** and the second turning axis **202** of the scribing line forming mechanism **201** is not limited to be restricted.

[00198] Figure **10** shows a structure of a scribing head **200'** which is another example of the scribing head. Figure **11** shows a structure of a scribing head **400'** which is another example of the scribing head. Figure **12** shows a structure of a scribing head **600'** which is another example of the scribing head. Figure **13** shows a structure of a scribing head **500'** which is another example of the scribing head.

[00199] In Figure **10** to Figure **13**, the same components as those shown in Figure **2**, Figure **6** and Figure **9** are denoted by the same reference numerals, and the description thereof will be omitted.

[00200] According to the scribing head **200'** the scribing head **400'** the scribing head **600'** and the scribing head **500'**, the turning about the first turning axis **204** and the second turning axis **202** is not restricted. The reason for this is that the holder body **205** and the holder **203** are provided so as to be positioned below the bearing case **225**, the holder holding member **404** or the holder holding member **504**.

[00201] The scribing head **200'**, the scribing head **400'**, the scribing head **600'** and the scribing head **500'** can be effectively employed in a state where the change of the processing reaction force received by the scribing line forming means **207** during the scribing operation is previously predicted and the turning of the holder body **205** is not so large even if a large change occurs.

[00202] At least one of the scribing head **200'**, the scribing head **400'**, the scribing head **600'** and the scribing head **500'** can be applied to the scribing apparatus **100** which has been described with reference to Figure **1**, instead of the scribing head **200** or in addition to the scribing head **200** which has been described with reference Figure **2**. The scribing apparatus **100** including at least one of the scribing head

200', the scribing head **400'**, the scribing head **600'** and the scribing head **500'** can perform the scribing line forming process procedure which has been described with reference to Figure 5 and Figure 7.

[00203] 10. Scribing apparatus including a multi-head

[00204] Figure **14** shows a structure of a scribing apparatus **800** which is another example of the scribing apparatus. In Figure **14**, the same components as those shown in Figure **1** are denoted by the same reference numerals, and the description thereof will be omitted.

[00205] The scribing apparatus **800** has the same structure as the scribing apparatus **100** which has been described with reference to Figure **1** except that in the scribing head **800**, a multi-head **900** is included, instead of the scribing head **200** included in the scribing apparatus **100**.

[00206] The multi-head **900** includes a plurality of scribing heads. The plurality of scribing heads includes at least one of the cylindrical cam-type scribing head **500** which has been described with reference to Figure **9** and the cylindrical cam-type scribing head **500'** which has been described with reference to Figure **14**.

[00207] According to the cylindrical cam-type scribing head **500** and the cylindrical cam-type scribing head **500'**, the servo motor **402** and the servo motor **502** are attached in a longitudinal direction. Thus, only a small amount of attachment space is needed. Therefore, when a plurality of scribing heads are mounted in a scribing apparatus, numerous scribing heads can be attached with a small amount of space when compared to a conventional scribing head having a motor mounted thereon.

[00208] The scribing apparatus according to the present invention runs the plurality of scribing heads simultaneously. Therefore, scribing lines, the number of which corresponds to the number of the plurality of scribing heads, are formed. As a

result, when a plurality of unit substrates are cut from one substrate, production efficiency can be improved.

[00209] The scribing apparatus **800** can perform the scribing line forming process procedure which has been described with reference to Figure **5** and Figure **7**.

[00210] For example, a scribing line forming processing program for causing to an execution of the function of the scribing head according to the present invention or the function of the scribing apparatus according to the present invention is stored in the scribing head according to the present invention or the scribing apparatus according to the present invention.

[00211] When the scribing head or scribing apparatus is shipped, the processing program can be previously stored in a storage means included in the scribing head or the scribing apparatus. Alternatively, after the scribing head or scribing apparatus is shipped, the processing program can be stored in the storage means. For example, a user can download a processing program with or without charge from a particular website on the Internet and install the processing program downloaded onto a scribing head or a scribing apparatus.

[00212] When a processing program is recorded in a computer-readable recording medium (e.g., flexible disc, CD-ROM and DVD-ROM), the processing program can be installed in a scribing head or a scribing apparatus by using an input device. The processing program installed is stored in the storage means.

[00213] As described above, the Embodiment according to the present invention has been described with reference to Figure **1** to Figure **14**.

[00214] The scribing line forming mechanism, the scribing head and the scribing apparatus according to the present invention can be applied to the cutting of, for example, a liquid crystal display panel, a plasma display panel, an organic EL panel,

an inorganic EL panel which are a kind of flat display panel, a transmissive projector substrate and a reflective projector substrate.

[00215] Furthermore, the scribing line forming mechanism, the scribing head and the scribing apparatus according to the present invention can be applied to the cutting of, for example, one single substrate (e.g., glass plate, glass substrate, quartz plate, quartz substrate, sapphire plate, sapphire substrate, semiconductor wafer, ceramic plate and ceramic substrate). Furthermore, the scribing line forming mechanism, the scribing head and the scribing apparatus according to the present invention can be effectively applied to the cutting of a bonded substrate for which a plurality of substrates are bonded.

[00216] As described above, the scribing line forming mechanism, the scribing line head and the scribing apparatus according to the present invention have been described above with reference to Figure 1 to Figure 14. However, the present invention should not be interpreted solely based on the embodiments described above. It is understood that the scope of the present invention should be interpreted solely based on the claims. It is also understood that those skilled in the art can implement equivalent scope of technology, based on the description of the present invention and common knowledge from the description of the detailed preferred embodiments of the present invention. Furthermore, it is understood that any patent, any patent application and any references cited in the present specification should be incorporated by reference in the present specification in the same manner as the contents are specifically described therein.

INDUSTRIAL APPLICABILITY

[00217] According to the scribing line forming mechanism, the scribing head and the scribing apparatus of the present invention, the scribing line forming means follows

the movement direction of the second turning axis owing to the caster effect, and at the same time, the scribing line forming means can turn in a manner such that an error between the scribing line forming means and a supporting means is smaller. As a result, it is possible to reduce the force which acts in the horizontal direction of the substrate between the scribing line forming means and the substrate, thereby preventing the occurrence of a horizontal crack. It is possible to prevent the meandering of the scribing line forming means and form a scribing line with a high degree of straightness.